REMARKS/ARGUMENTS

Upon entry of this Amendment, Claims 92-159 will be pending in this application. Of these pending Claims, Claims 92, 93, 94, 95, 96, 97, 98, 99, 100, 101, 102 and 131 are in independent form. Claims 1, 2, 4-9, 12, 13, 16-23, 47, 48, 50-55, 58, 59, and 62-91 have been canceled without prejudice by this Amendment, and Applicants respectfully reserve the right to pursue claims of the comparable scope in one or more continuing applications in the future. Claims 3, 10, 11, 14, 15, 24-46, 49, 56, 57, 60 and 61 had been canceled previously. Claims 92-101, which have been allowed by the Examiner (see Par. 26 of the August 24, 2005 Office Action) remain un-amended.

Claims 102-159 have been newly added by this Amendment. All of the newly added claims require computation of memory addresses in a multiplanar frame buffer for the three-dimensional image data, using the coordinate information for the three-dimensional image data and information as to the pixel dimensions of the three-dimensional volumetric display. (Each memory address corresponds to a pixel to be displayed on the three-dimensional volumetric display.) The newly added claims also require assignment of the three-dimensional image data to their respective computed memory addresses in the multiplanar frame buffer.

More specifically, new independent method Claim 102 requires the foregoing computing and assigning steps. Likewise, new independent system Claim 131 requires a graphics data processor for performing the corresponding computation and assignment. These amendments are intended to more clearly capture the inventive features disclosed

in, *inter alia*, Pars. [0059]-[0065] and [0081]-[0083] of the specification[1], and steps 520 and 525 of FIG. 5a and steps 572 and 580 of FIG. 5d of the present application.

Applicants respectfully submit that these newly added claims are fully supported by the specification as filed and that no new matter has been introduced by this Amendment.

Applicants now address the August 24, 2005 Office Action.

Claim Rejections - 35 U.S.C. § 103

In Pars. 1-24 of the August 24, 2005 Office Action, the Examiner rejected Claims 1, 2, 4, 5, 7, 9, 12, 13, 16-23, 47, 48, 50, 51, 53, 55, 58, 59, 62-69 and 76-91 under 35 U.S.C. § 103(a) as being unpatentable over U.S. Patent No. 5,760,781 to Kaufman et al. ("the '781 Patent") in view of U.S. Patent No. 5,801,666 to MacFarlane ("the '666 Patent"). Applicants respectfully submit that, in view of the cancellation of these Claims without prejudice by this Amendment, it is respectfully submitted that the Examiner's rejection of Claims 1, 2, 4, 5, 7, 9, 12, 13, 16-23, 47, 48, 50, 51, 53, 55, 58, 59, 62-69 and 76-91 under 35 U.S.C. § 103(a) has been rendered moot. Applicants disagree with the Examiner's rejection of these Claims and still maintain their previously stated position that the '781 Patent does not disclose a multiplanar frame buffer, as claimed, that stores three-dimensional image data to be displayed on a three-dimensional volumetric display. Although Applicants do not need to address the merits of the

[1] All citations to the specification of the present application in this Amendment refer to the paragraph numbers appearing in U.S. Patent Application Publication No. US 2002/0085000 A1.

rejection at this time, in view of the claim amendments submitted herewith, we consider it important to note the following:

First, by way of background, Applicants respectfully note that there is a significant body of prior art directed to the processing of three-dimensional data, but for ultimate display on a two-dimensional screen, such as a computer monitor. For example, in the computed tomography field and in particular the use of medical x-ray tomography machines, x-rays are taken along different paths through a human body, and a mathematical formula is used to compute, from the attenuation of the x-ray beam as it goes through the body, the x-ray density n(x,y,z) within the volume scanned by the x-ray beams. However, in order to display an image on a 2-D computer monitor, the three-dimensional x-ray density data n(x,y,z) ultimately needs to be converted to two-dimensional display data. Such dimensional display data tells the computer monitor what color and brightness to provide at each two-dimensional pixel position (x,y) of the computer monitor.

The cited '781 Patent is directed to a system of this general type, in which three-dimensional volumetric data is processed for display on a two-dimensional screen, such as a conventional 2-D computer monitor. It discloses a method and apparatus for generating three-dimensional volume projection images of an object from a desired viewing direction. (the '781 Patent, Col. 2, lines 60-66). It is well known in the field of mathematics and three-dimensional computer graphics that three-dimensional projection is "a mathematical process to project a series of 3D shapes to a 2D surface, usually a

computer monitor." (WIKIPEDIA, The Free Encyclopedia, at http://en.wikipedia.org/wiki/3D_projection (last visited November 22, 2004)) (emphasis added). In other words, the '781 Patent is directed to generating images of a three-dimensional object on a conventional 2D display that are perceived to be three dimensional on the same basis that a computer screen image may be perceived to be "three dimensional."

More specifically, FIG. 3 of the '781 Patent shows a projection mechanism (RPC) 32, which receives interpolated voxel values from an interpolation mechanism 28, combines the interpolated voxel values, and generates a pixel value for each viewing ray. (the '781 Patent, Col. 9, lines 5-9). Each viewing ray corresponds to each pixel of the display screen. (the '781 Patent, Col. 4, lines 14-15). "Preferably, the pixel value signal generated by the projection mechanism 32 is provided to the frame buffer 40 where each pixel value signal is stored, provided to the pixel processor 42 for 2-D transformation, filtering or warping, and thereafter provided to a display device 44 for visual display." (the '781 Patent, Col. 10, lines 29-34) (emphasis added). Another embodiment shown in FIG. 12 of the '781 Patent likewise uses "a pixel processor 42, frame buffer 40, and display device 44 for generating the three-dimensional (3-D) volume projection image." (the '781 Patent, Col. 13, lines 60-63) (emphasis added). Nowhere in the '781 Patent is there any disclosure or even suggestion of displaying three-dimensional image on a truly three-dimensional volumetric display.

In contrast to a 2-D computer monitor, the three-dimensional volumetric display described in the present application is a true volumetric display in that corresponding slices of a three-dimensional image are displayed in sequence on a plurality of screens (i.e., on optical elements 115, 120 and 125 shown in FIG. 1 of the present application).

In a conventional 2-D display, three-dimensional "raw" data (such as the above-mentioned density data n(x,y,z)) is processed by various means and ultimately converted into color and brightness information for each x,y pixel. The final (x,y) image data is stored in a 2-D "frame buffer." In the display field, a "frame buffer" is understood to be a buffer that holds image data (e.g., color and brightness values) that is output to the 2-D display. More specifically, the use of the term "frame buffer" is understood by workers of skill in graphics processing to represent a special purpose display buffer that holds such image data, whose addresses therefore have a one-to-one correspondence with the pixels (x,y) that are displayed.

In the present application, when there are a plurality of display screens that are sequentially energized to display slices of an image along a real depth axis, the three-dimensional image data to be displayed on this plurality of display screens needs to be stored in a three-dimensional multiplanar frame buffer, which stores for each pixel (x,y) to be displayed on a particular screen (at location z), the color, brightness and possibly other values (e.g., transparency) associated with such pixels. This leads to a fundamental difference in organization between the 2-D frame buffer for a two-

dimensional display and the multiplanar frame buffer for a three-dimensional volumetric display.

In the case of a three-dimensional volumetric display where the z coordinate now becomes an actual coordinate of the display itself, this invention discloses efficient ways for computing the (x,y,z) addresses in a multiplanar frame buffer and methods of processing image data that is stored at those (x,y,z) addresses which takes into account transparency effects, etc.

Particularly, all of the newly added claims expressly require computation of memory addresses in a multiplanar frame buffer for the three-dimensional image data using the coordinate information of the image data (e.g., the (x,y,z) coordinates) and information as to the pixel dimensions of the three-dimensional display (e.g., the number of pixels that can be accommodated by the three-dimensional volumetric display in the x and y directions). As taught by this application, this direct computation of the corresponding memory addresses for the image data provides an efficient way to rasterize the image data for a three-dimensional volumetric display.

As for the '781 Patent, as discussed above and as previously stated in the responses to the prior Office Actions, it is directed to a system for processing three-dimensional data using ray casting techniques that are used to project three-dimensional data onto a two-dimensional display screen. Furthermore, the '781 Patent does not disclose a multiplanar frame buffer having addressable memory locations corresponding to pixels of display elements of a three-dimensional volumetric display. FIGS. 3 and 12

of the '781 Patent show that it is a frame buffer 40, not the cubic frame buffer 22, that stores pixel values for the display device 44. (the '781 Patent, Col. 10, lines 29-34). The cubic frame buffer 22, coupled to the data acquisition device 23, is merely a data buffer for storing acquired image data or voxels before the image data undergoes various processes and interpolations (via one or more two-dimensional buffers 24) to be stored in the frame buffer 40 and displayed on the display device 44 as volume projection images. (the '781 Patent, Col. 6, lines 22-48). As a result, the display buffer in the '781 Patent is a 2-D buffer storing (x,y) pixel information. The '781 Patent does not disclose or suggest a multiplanar frame buffer for storing three-dimensional image data that is displayed on a three-dimensional volumetric display.

Turning to the '666 Patent, it is directed to a three-dimensional computer monitor comprising a three-dimensional array of optical voxels which are individually activated by light energy transmitted through optical fibers. Again, unlike the present invention, the '666 Patent does not teach or suggest use of a multiplanar frame buffer for storing the three-dimensional image data to be displayed on a 3-D volumetric display.

Accordingly, Applicants respectfully submit that neither the '781 Patent nor the '666 Patent discloses a multiplanar frame buffer for storing three-dimensional image data to be displayed on a three-dimensional volumetric display, which is required by both the rejected claims as well as the newly added claims.

In all events, since all of the newly added claims explicitly require computation of memory addresses in a multiplanar frame buffer for the three-dimensional image data

using the coordinate information of the image data and information as to the pixel dimensions of the three-dimensional display, Applicants respectfully submit that these new claims are allowable over the cited '781 and '666 Patents on this ground alone. More specifically, nowhere in either the '781 Patent or in the '666 Patent is there any teaching or suggestion of the inventive feature claimed herein of computing memory addresses in a multiplanar frame buffer for the image data. It also naturally follows that the specific use of the coordinate information contained in the image data as well as information as to the pixel dimensions of the three-dimensional volumetric display in making such computation of memory addresses is not disclosed or suggested by the '781 Patent or the '666 Patent.

To establish *prima facie* obviousness of a claimed invention under 35 U.S.C. § 103(a), all of the claim limitations must be taught or suggested by the prior art. MPEP 2143.03. Since neither the '781 Patent, nor the '666 Patent teaches or suggests computation of memory addresses in a multiplanar frame buffer, a claim element required by all of the newly added claims, the '781 Patent and the '666 Patent, either individually or in combination, do not render any of the newly added claim obvious. Accordingly, it is respectfully requested that newly added Claims 102-159 be allowed over the '781 and '666 Patents.

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In light of the foregoing amendments and remarks, Applicants respectfully request that a timely Notice of Allowance with respect to all of the pending claims be issued.

Included herewith is a petition for a two-month extension of time. A check in the amount of $225.00 is also included herewith to cover the fee for a two-month extension of time for response for a small entity. No additional fees or extensions of time are believed to be due in connection with filing of this Amendment. However, authorization is given hereby to charge Deposit Account No. 01-1785 for any deficiency in fees necessary to preserve the pendency of the subject application, or to credit the same in case of overpayment.

Respectfully submitted,

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